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Patent Application No. 09/786,140
Inventors: Matthys, E.F. and Gasljevic, K.
Filed: February 28, 2001
For: METHODS TO CONTROL HEAT TRANSFER IN FLUIDS CONTAINING DRAG-REDUCING AGENTS

Examiner: Patel, Nihir B.
Group art Unit 3743

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APPEAL BRIEF

Commissioner for Patents
P.O. Box 1450
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Dear Sir:

Please enter the following Appeal Brief, filed by the applicants *pro se*. The fee of $165 (check) is enclosed, as well as three copies of references: Kawaguchi, et al. US Patent No 6,112,806 and Brown US Patent No. 4,702,312.

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Date of Signature

Feb 19, 2004

Kazimir Gasljevic

1) **Real party in interest**

Real parties in interest are patent applicants Kazimir Gasljevic and Eric F. Matthys

2) **Related Appeals and interferences**

There are no related appeals and interferences known to appellants.

3) **Status of Claims**

Claim 1) Rejected
Claim 2) Rejected
Claim 1) Rejected
Claim 2) Rejected
Claim 3) Rejected
Claim 4) Rejected
Claim 5) Rejected
Claim 6) Rejected
Claim 7) Rejected
Claim 8) Rejected
Claim 9) Rejected
Claim 10) Rejected
Claim 11) Rejected
Claim 12) Rejected
Claim 13) Rejected
Claim 14) Rejected
Claim 15) Rejected
Claim 16) Rejected
Claim 17) Rejected
Claim 18) Rejected
Claim 19) Rejected
Claim 20) Rejected
Claim 21) Rejected
Claim 22) Rejected
Claim 23) Rejected
Claim 24) Rejected
Claim 25) Rejected
Claim 26) Rejected

4) **Status of Amendmends**

No amendments were filed subsequent to final rejection.

5) **Summary of Invention**

Drag-reducing surfactant solutions are water solutions of surfactants, *i.e.*, within acceptable simplification, water solutions of special soaps. Those solutions demonstrate elastic behavior, normally found in solids, but not liquids. They fall out of the field of standard Newtonian Fluid Mechanics, and very few scientists are familiar with drag reducing phenomenon (probably less than 10 groups of scientists in the whole world, typically at universities, currently work on the problem of drag reduction). Drag reduction results from the very peculiar ability of such solutions to reduce friction coefficient in turbulent flow, and that, in turn reduce (by the same factor) the pumping power needed. The use of a very small amount of surfactants in water circulating in a building's heating or cooling system can reduce the necessary pumping power by a factor of 5. Unfortunately, such a huge energy saving cannot be readily exploited in practice, because of a heat transfer problem, as we have shown in few extensive field tests. When reducing the drag by reducing the turbulence of the flow, the surfactant structures in the fluid inevitably reduce the heat transfer. If friction is reduced by a factor of 5, heat transfer is reduced by a factor of 10 (both relative to clean water, without a surfactant additive). This is generally unacceptable. The technology of drag reduction by surfactant additives becomes feasible for practical applications and offers an opportunity for spectacular energy savings only if heat transfer can be recovered to the level of heat transfer of pure water (**heat transfer recovery**).

The heat transfer recovery cannot be achieved by **methods used for heat transfer enhancement used for Newtonian fluids (our Spec. page 3 lines 9 to 13)**. There are many patented solutions which can increase heat transfer of fluids (like Brown's packing of thin rods or Kawaguchi's irregularities of the heat transfer plate[1], both used by the Examiner in his rejection of our claims) **which all affect the flow**, or, more precisely, the boundary layer, by increasing mixing of the fluid. However, those methods are useless for drag-reducing fluids. As long as surfactant structures in water solution inhibit turbulence in the flow, it is practically impossible to recover the good heat transfer of pure water.

The nature of drag-reducing surfactant solutions is very different from polymer solutions, which are more prominent and more studied drag-reducing solutions. Polymer molecules are large enough to affect the turbulence in the flow and generate a drag-reducing effect. Surfactant molecules are much smaller than polymer molecules, but they form in water so called micellar structures, which are large enough to generate drag-

[1] An essential part of Kawaguchi's idea is degrading the drag reducing surfactant solution by high temperature (this affects the fluid). That should be distinguished from additional effect, which he claims to achieve by "heat transfer plate formed with irregularities" (this affects the flow).

reducing effects. Association of surfactant molecules into micelles, as well as breaking of micelles in individual molecules, is governed by the laws of molecular thermodynamics. Surfactant solution (surfactant molecules dissolved in water), under conditions which favor formation of micelles, is a viscoelastic solution (it is really elastic, almost like liquid rubber), and it facilitates drag reduction in turbulent flow. If conditions change (temperature, for example, which is the idea underlying Kawaguchi's patent), causing micelles to dissociate, the solution will behave like pure water and there will be no drag reducing effects.

Besides thermodynamic states (like temperature and pressure), mechanical stress in the surfactant solution may control the formation and breaking of micelles (our Spec. page 4 lines 6 to 9). The effect of stress on micellar dynamics is not instantaneous, but there are time parameters involved. A certain time of exposure of micelles to a given level of stress is needed for micelles to break (degrade), just as a certain recovery time is needed for micelles to recover after being degraded. Those time parameters depend on surfactant solution and level of stress.

After many years of studying the dynamics of micellar breaking and recovery under exposure to mechanical stress, we discovered that we can use different means of imposing mechanical stress on drag-reducing surfactant solutions and **change the fluid** from a drag-reducing, viscoelastic solution into a fluid which behaves as pure water and vice versa (our Spec. page 5 lines 1 to 10). This discovery is the basic idea of our invention. With micelles in surfactant solution broken (for a time of stress exposure, plus time needed for micellar recovery after cessation of the exposure to stress), the solution provides no drag reduction, but the heat transfer is equal to the heat transfer of pure water, which means 10 times higher than with non-degraded fluid (our Spec. page 5 lines 1 to 7). That essentially means that, by manipulating the shear stress the surfactant solution is exposed to, **one can turn on and of drag reducing effects (and coupled undesired heat transfer reduction),** allowing drag reduction and pumping power savings in the whole circulation system, except heat exchangers, while maintaining good heat transfer in heat exchangers.

Efficiency of degradation, which means using the minimum energy needed for degradation, is achieved by degrading devices which impose a uniform stress across the flow cross section, like wire mesh inserts and similar devices (our Spec. page 7 lines 16 to 24 and page 8 lines 1 to 3). Customizing a fluid (surfactant additive type and concentration) to achieve desirable degradation and recovery characteristics is part of the invention as well (our Spec. page 4 lines 10 to 12 and lines 14 to 18).

6) **Issues**

a) Whether claims 1-7, 9, 10, 14, 17, 18, 23-26 are unpatentable under USC 102(e), as being anticipated by Kawaguchi et al. US Patent No 6,112,806.
b) Whether claims 11, 12, 13, 15, 16, 19, 20, 21 and 22 are unpatentable under USC 103(a) over combined teachings of Kawaguchi et al. US Patent No 6,112,806 and Brown US Patent No. 4,702,312.

7) **Grouping of Claims**

a) Claims rejected under USC 102(e)

Claims 6, 7 and 8 should be considered as a separate group.

b) Claims rejected under USC 103(a)

All claims rejected under this ground stand together.

8) **Argument**

CLAIMS REJECTION UNDER 35U.S.C. 102(e)

Our invention is a method of heat transfer recovery in heat exchangers when drag-reducing surfactant solution (in further text, "drag-reducing solution") is used as heat exchanging fluid. The drag reducing solution is used instead of water to reduce friction losses and necessary pumping power. However, use of drag-reducing solution reduces not only friction, but heat transfer as well. Heat transfer recovery stands for recovering heat transfer with drag reducing solution to the level of heat transfer that would be achieved if water were used as heat exchanging fluid rather than drag reducing solution. **Our invention only applies to and makes sense in terms of those drag-reducing solutions**.

Our method of heat transfer recovery of drag reducing solutions consists of breaking the surfactant micelles in the drag reducing solution by intentionally imposed shear stress and temporarily converting drag reducing solution to non-drag-reducing fluid, which behaves in all aspects like water (good heat transfer). The necessary stress, which is well defined (critical shear stress), depends on the drag-reducing solution (whose properties and chemical constitution are part of the invention too). Different devices are recommended for the purpose of intentional degradation and are part of the invention as well.

Kawaguchi is teaching a method of heat transfer recovery for the same type of drag-reducing solutions by thermal degradation. His method relies on breaking micelles by the exposure to extreme temperatures. **He does not mention micellar degradation by shear stress**. He does mention irregularities of the heat transfer plate, which supposedly increase heat transfer, as an **additional means of increasing heat transfer of a thermally degraded fluid.** He is very explicit, reciting modification of the boundary layer and increased fluid mixing by the use of the heat transfer plate irregularities, which intended use

in turn increases heat transfer, **but he does not mention nor imply breaking micelles (degradation of the fluid) by those irregularities**. **His irregularities, which promote mixing, are intended to affect the flow. Our invention, on the contrary, affects (changes) the very fluid (converting it temporarily from a drag reducing solution to an ordinary, water like fluid).** Increased mixing is a very common method of increasing the heat transfer, and many patented devices based on this principle exist. Of course, any increased mixing necessarily increases the shear stress imposed on the fluid. Note that, in these methods of increasing heat transfer, the imposed stress is an unwelcome, but unavoidable, by-effect of increased mixing, which is the desirable effect. One can increase mixing of a drag-reducing solution by any device, like Kavaguchi's plate with irregularities, but heat transfer will not be recovered to the level of heat transfer which would be achieved if water were used instead of a drag reducing solution, unless the micelles are temporarily destroyed. That is obvious from the following example. A drag-reducing solution, which reduces friction and pumping power for a factor of 5 (relative to water), reduces heat transfer by a factor of 10 (again relative to water). It is not only impractical (due to enormous pumping power needed), but also impossible to increase heat transfer by a factor of 10 by the use of any device which increases mixing. To recover the heat transfer, the fluid should be temporarily changed by breaking the micelles and their structures which surfactant molecules form in water.

The Examiner takes Kawaguchi's recitation of the heat transfer plate's irregularities as an implication that those irregularities impose some shear stress to the fluid. Of course, any component of the flow system (pump, valve, fitting, even the pipe conveying the fluid) imposes some stress to the fluid. However, those components of the system (just as Kawaguchi's heat transfer plate irregularities) will not degrade the fluid unless they are designed specifically to impose the exactly predetermined uniform shear stress (critical shear stress) which is needed to degrade a particular drag reducing solution. Note that the fluid properties (type of a surfactant additive and concentration) have to be tailored such that not an unacceptably high stress would be needed for degradation, because the power needed to impose this stress would cancel or surpass the pumping power savings achieved by drag reduction. Adjusting the fluid degradation properties (critical shear stress, recovery time) as a function of the fluid temperature is a component of our invention. To make use of the shear stress for the temporary degradation of drag reducing solution knowledge of someone skilled in art is not sufficient. Indeed, to apply the idea of intentional degradation of the drag reducing fluid for the purpose of the heat transfer recovery, one would have to posses a very thorough understanding of the behavior of drag-reducing surfactant solutions, a result of many years of our research (not disclosed before our patent application), as well as a capacity to make a non-obvious use of that understanding towards our invention.

Re. Grouping of the Claims 6, 7 and 8.

Claims 6, 7, and 8 are based on the idea that the recovery characteristic of a degraded fluid can be made temperature independent. Temperature independence of recovery time is critical in applications where circulating fluid is exposed to a range of temperatures. Such independence can be achieved by mixing two types of surfactants that exhibit opposite effects of temperature on their recovery kinetics, namely nonionic and cationic surfactant (see our Specification page 17 line 8 to page 18 line 11).

Conditioning of the fluid for the control of the degradation and recovery characteristic of a surfactant solution, degraded by shear stress, is part of our invention, in general. However, to apply the idea of the mixing of two types of surfactants to balance the opposite effect of temperature on their kinetics of micelle formation, one has to rely on the evidence provided by our experiments, not yet published and, to our knowledge, not available in literature. Consequently, claims 6, 7, and 8, which are based on that specific idea, should be considered as patentable separately from the rest of the claims.

CLAIMS REJECTION UNDER 35 USC 103

The Examiner is combining the teachings of Kawaguchi with those of Brown to reject our claims 11, 12, 13, 15, 19, and 20-22. There is no suggestion to combine those references in both of the references cited, neither any prior art, towards the effect claimed by our invention. The scope of Brown's invention is not at all related to heat transfer enhancement of liquids, but rather to heat transfer of high temperature gasses (heat transfer by radiation). If applied to the flow of heat exchanging liquids, Brown's thin rod packing may increase turbulence and mixing of flowing liquid, and consequently improve heat transfer, by the method of affecting the flow. Our invention does work by affecting the fluid, as explained in the section dealing with Claim rejection under 35U.S.C. 102(e). The Examiner argues that such a device would impose a uniform shear stress to a drag-reducing fluid, as is claimed for our degrading device. That may be true, and the concentration of stress may be high enough to degrade the fluid if the rods are very small and densely packed, because in such an extreme modification of Brown's device it would resemble a wire mesh insert recited in our claims. However, the intention of degrading the micelles is missing and it cannot be derived from Kawaguchi's disclosure either although the Examiner seems to imply so. Following the Examiner's construction, **Brown's thin rod packing would have a new use, not anticipated either by Brown or by Kawaguchi.**

Appendex

We claim.

1. An improvement in a hydronic system including a heat exchanger when using a drag-reducing surfactant solution as a thermal distribution fluid comprising:

(see page 3 lines 1-10)

a surfactant solution flowing through said heat exchanger, which surfactant reduces fluid drag within said hydronic system, but not necessarily within said heat exchanger, said surfactant solution characterized by an optimized recovery time as defined by ability of said surfactant solution to rebuild molecular or micellar structures after disruption of said molecular or micellar structures; and intended use

(5; see ~~page~~ ~~8~~ column 3 lines 10-20)

a fluid degradation device to create temporary fluid degradation in said heat exchanger to break or disrupt said molecular or micellar structures in said surfactant solution by high local shear stresses so that heat transfer rate of said surfactant solution is increased in the heat exchanger for a predetermined distance or time downstream from said degradation device, during which recovery time said molecular or micellar structures are being rebuilt, subsequent to which full drag and heat transfer reductions are again achieved, intended use

whereby heat exchanger efficiency is recovered to an original level obtained without surfactant to achieve overall energy savings in said hydronic system.

2. An improvement in a method of heat exchange in a hydronic system comprising:

providing a surfactant solution as a heat exchanging fluid in a heat exchanger included within said hydronic system, which surfactant solution reduces fluid drag within said hydronic system, said surfactant solution characterized by a predetermined recovery time as defined by ability of said surfactant solution to rebuild molecular or micellar structures after disruption of said molecular or micellar structures; and disturbing flow in said heat exchanger to break or disrupt said molecular or micellar structures in said surfactant solution by high local shear stresses so that heat transfer rate of said surfactant solution is returned to a level approximating heat transfer rate of said heat exchanging fluid without said surfactant added for a predetermined distance downstream from said disturbance during said recovery time during which said molecular or micellar structures are being rebuilt.

intended use

3. A method of heat transfer recovery in turbulent flow of drag reducing surfactant solutions comprising

providing a degrading device which degrades the fluid with minimum pressure drop;

creating temporary degradation of a circulating fluid; and

conditioning of the drag reducing fluid properties relevant for degradation and recovery.

4. A fluid having optimized properties of degradation and recovery comprising:

a thermal transport fluid; and

a surfactant additive capable of withstanding stress in all pipes and fittings of a circulation system and providing asymptotic drag reduction in straight pipes, and some drag reduction in fittings, whereas in a heat exchanger in which said fluid is degraded by a degrading device, the drag and heat transfer reductions are temporarily substantially eliminated, said fluid remaining substantially degraded during its residence in said heat exchanger after which recovery occurs quickly after said fluid exits from heat exchanger.

5. The fluid of claim 4 where said fluid and surfactant in combination are characterized by a drag reduction recovery having a long dead time at substantially reduced drag reduction and a fast recovery to a substantially undegraded drag reduction level.

6. A fluid having optimized properties of degradation and recovery comprising:

a thermal transport fluid; and

a surfactant additive having, when added to said thermal transport fluid, a substantial independence of drag-reducing ability, degradation, and recovery properties as a function of temperature.

7. The fluid of claim 6 wherein said surfactant additive comprises a mixture of surfactants with opposing effects of temperature on drag-reducing ability, degradation, and recovery time.

8. The fluid of claim 7 where said mixture of surfactants comprises a cationic surfactant and a nonionic surfactant in which opposing effects of said cationic surfactant and nonionic surfactant substantially cancel each other to provide a substantially temperature independent surfactant additive.

9. A heat exchanger comprising:

a first heat exchanging fluid path; 3

a second heat exchanging fluid 4 path, wherein at least one of said first and second heat exchanging fluid paths further comprises a dedicated degrading device disposed therein; and

a heat exchanging fluid with a temporarily degradable drag reducing surfactant additive disposed in said corresponding heat exchanging fluid path.

10. The heat exchanger of claim 9 wherein said dedicated device is used exclusively for degrading a heat exchanging fluid flowing through said heat exchanger.

11. The heat exchanger of claim 9 wherein said dedicated degrading device imposes a flow disturbance or shear stress uniformly across a cross section of said corresponding heat exchanging fluid path in which said dedicated degrading device is disposed.

12. The heat exchanger of claim 11 wherein said dedicated degrading device exposes every surfactant particle flowing in said corresponding heat exchanging fluid path to at least a supercritical stress.

13. The heat exchanger of claim 12 wherein said stress imposed by said dedicated degrading device is not significantly higher than said supercritical stress so that the flow energy needed for degradation is minimized.

14. The heat exchanger of claim 9 wherein said dedicated degrading device is disposed at or near an inlet to said corresponding heat exchanging fluid path.

15. The heat exchanger of claim 9 wherein said dedicated degrading device comprises a wire mesh disposed across said corresponding heat exchanging fluid path.

16. The heat exchanger of claim 15 wherein said wire mesh also functions as a filter.

17. A heat exchanger comprising:

a first heat exchanging fluid path; 3

a second heat exchanging fluid path, 4 wherein at least a corresponding one of said first and second heat exchanging fluid paths further comprises a conventional hydraulic component normally found in a circulation system, which hydraulic component is disposed upstream and in proximity to said corresponding heat exchanging fluid path; and

a heat exchanging fluid with a temporarily degradable drag reducing surfactant additive disposed in said corresponding heat exchanging fluid path.

18. A method of heat transfer recovery in turbulent flow in a heat exchanger by means of a drag reducing surfactant fluid characterized by degradation and recovery of drag reducing fluid properties comprising:

conditioning said drag reducing fluid properties of said drag reducing surfactant fluid;

providing a degrading device which degrades the fluid with minimum pressure drop;

creating an initial temporary degradation of a circulating fluid in a flow of said fluid in said heat exchanger; and

after said fluid is initially degraded, creating additional disturbances in said flow to prevent recovery of the fluid.

19. The method of claim 18 where a smaller pressure drop than the one used for said initial degradation upstream of heat exchanger is used to create said smaller disturbance.

2 20. The method of claim 19 where conditioning said drag reducing fluid properties of said drag reducing surfactant fluid with a faster recovery to achieve asymptotic drag reduction immediately downstream from said heat exchanger.

2. 21. The method of claim 19 where conditioning said drag reducing fluid properties of said drag reducing surfactant fluid by pipe stress to use shear stress generated by said heat exchanging fluid paths of said heat exchanger to degrade said fluid.

7. 22. The method of claim 9 where conditioning said drag reducing fluid properties of said drag reducing surfactant fluid by pipe stress to use shear

stress generated by said heat exchanging fluid paths of said heat exchanger to prevent said fluid degraded by said degrading device from recovering.

23. The improvement of claim 2 further comprising maintaining flow rate of said heat exchanging fluid in said hydronic system, while flow rate of said heat exchanging fluid in said heat exchanger is increased in the heat exchanger through the addition of a secondary pump located in parallel with the heat exchanger a~~nd connected to the inlet and outlet of the heat exchanger.~~

24. A fluid comprising:

a base component; and

a surfactant having drag-reducing, fluid degradation, and fluid recovery properties which are substantially independent of temperature when combined with said base component.

25. A method of characterizing degradability of a fluid and degradation work imposed on a fluid comprising:

providing a flow of said fluid;

providing a degrading device in said flow to degrade said drag reducing properties of said fluid;

creating a pressure drop across said degrading device; and

measuring said pressure drop as an indicator of resistance to degradation of said drag reducing properties in said fluid, as well as an indicator of the degradation work imposed on the fluid.

26. A method of managing degradability of a fluid and degradation work imposed on a fluid comprising:

providing a flow of said fluid;

providing a degrading device in said flow to degrade said drag reducing properties of said fluid;

creating a pressure drop across said degrading device; and

providing a predetermined amount of time after degradation of said drag reducing properties of said fluid to allow recovery of said fluid without additional degradation work being performed, said predetermined amount of time being independent of velocity of said fluid.

27. A method of increasing heat transfer in a hydronic system having a heat exchanger over nominal design limits, said heat exchanger having a heat transport fluid therein which is characterized by a heat transfer rate, comprising:

adding a surfactant to said heat transport fluid to reduce drag in said hydronic system;

providing a flow of said heat transport fluid and said surfactant through said heat exchanger at an increased rate over said nominal design limits; and

providing a degrading device in said flow in said heat exchanger to degrade said drag reducing properties of said surfactant in order to increase said heat transfer rate of said heat transport fluid in said heat exchanger.